LTE1800:

A Versatile Platform for Connected Devices and Applications

SIERRA WIRELESS™

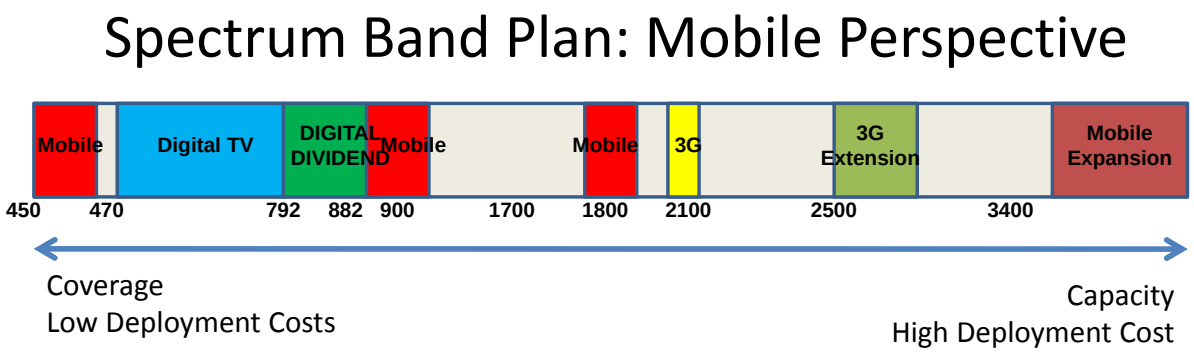
Contents

Executive Summary

LTE is quickly becoming the de facto standard for the next generation of mobile data services. With fast data rates, low latency, and good coverage, LTE can deliver an excellent experience for users, and a range of business and technology benefits for network operators, device manufacturers and other stakeholders.

One of the most significant trends now unfolding in the wireless industry is the growth in LTE services using the 1800 MHz frequency band, or Band 3. Well positioned between low-bandwidth and high-bandwidth parts of the spectrum, Band 3 provides an attractive combination of capacity and coverage (Figure 1). And, since 1800 MHz is already widely used by operators for 2G GSM services, it also provides a cost-effective solution for boosting mobile broadband capacity—allowing operators to re-farm spectrum they already own for LTE, instead of (or in addition to) licensing new spectrum. Given these advantages, it's easy to see why LTE1800 is gaining traction in many parts of the world, most notably in Europe, Asia and Oceania, as an ideal foundation for LTE services and connected devices.

Figure 1. LTE Effectively Balances Capacity and Coverage
(Source: GSM Association 2009)



However, LTE1800 (and LTE in general) poses unique challenges for those designing products and applications to take advantage of it. The most significant: accounting for diverse cellular networking environments. LTE networks are in varying stages of deployment in different markets, and different operators are implementing LTE in different ways—making product development for a global marketplace more complex and potentially costly. For the foreseeable future, most users will also have access to pockets of LTE service separated by

large areas of non-LTE coverage. Any practical LTE1800 solution must therefore be capable of handing off effectively between LTE, 3G, and 2G technologies, often across multiple frequency bands. This will require intelligent multi-mode/multi-frequency solutions that can deliver the best possible experience regardless of where or how the user is connecting. Connected device manufacturers will need to carefully weigh the impact these and other design considerations will have on their planned products. System integrators and application developers need to understand these complexities as well to properly assess their communications requirements and meet target customers' needs.

This paper examines the growing industry adoption of LTE and LTE1800, and the reasons for this growth. It discusses the unique requirements of LTE1800 and how device manufacturers and application developers can most effectively meet them. Finally, the paper details the best practices and qualifications that should be considered when evaluating cellular technology partners for LTE-connected devices and applications.

The Rise of LTE

The market has made its choice for the next generation of high-speed mobile broadband technologies, and the industry is coalescing around LTE. The Global mobile Suppliers Association (GSA) reports that, as of May 2011, 208 operators in 80 countries are investing in 3GPP LTE systems. Indeed, GSA notes that compared with recent mobile system rollouts such as those for HSDPA and HSUPA, LTE is the fastest developing mobile system technology in the history of the industry. Even among network operators that have migrated to or are expanding HSPA+ deployments, many now view LTE as the eventual unifying technology for their mobile broadband networks.

Several drivers account for this growth. Primarily, LTE provides a number of benefits that directly enhance the user experience, including:

- **Faster data rates:** Devices connecting via LTE can provide much higher capacity and data rates than previous-generation mobile data technologies—as much as 100 Mbps/50 Mbps download/upload speeds—to power a broad range of new mobile broadband, video, cloud computing, and other connected device applications. Future generations of LTE, such as LTE-Advanced, will support even faster speeds.

- **Lower latency:** Latency can have an even more significant impact on the user experience than data rates. A 3G network with 100-millisecond latency, for example, will take several seconds to load a standard web page regardless of the connection speed, simply due to the number of messages that must be passed back and forth between the device and the web server. LTE provides as much as 10 times lower latency compared to 3G technologies, delivering an immediate and noticeable improvement for the user.

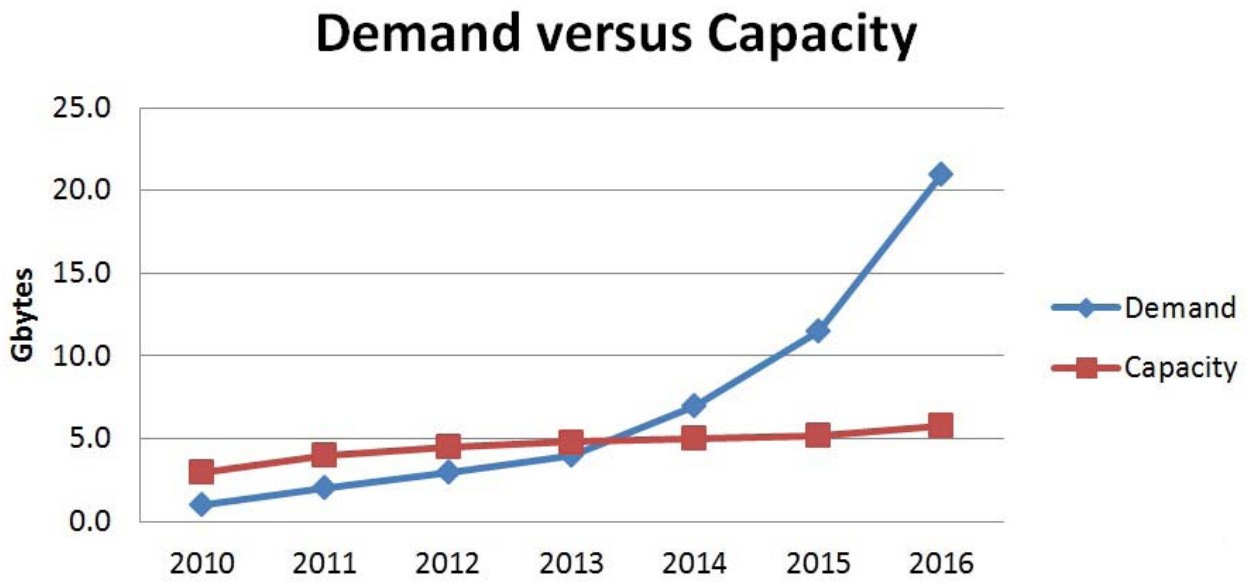
- **Improved system design:** The streamlined control plane and data plane design in LTE networks enables better performance in mobile applications and simplifies handoffs to 2G and 3G access systems, making them transparent to users.

Operators have sound business and financial reasons to adopt LTE as well. As an all-IP technology, LTE simplifies core and transport networks, making them less expensive to deploy and maintain. In addition, LTE is scalable to operate in multiple allocations (1.4 MHz through 20 MHz), uplink and downlink, paired (FDD) and unpaired (TDD) mode, etc.

Perhaps even more significant for operators, LTE solves one of the most pressing problems in the cellular industry: the dwindling supply of wireless spectrum available to meet insatiable demand for broadband mobile data services (Figure 2). The Cisco Visual Networking Index (VNI) projects mobile data traffic to nearly double each year between now and 2015, reaching 26 times the amount of mobile traffic in 2010[1]. LTE affords carriers much greater flexibility to accommodate this demand, even if they can't add new spectrum. IDATE estimates that total worldwide mobile traffic will reach more than 127 exabytes in 2020—33 times the total mobile traffic in 2010.

[1] "Cisco Visual Networking Index: Forecast and Methodology, 2010-2015." 1 June 2011. Cisco VNI. http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360_ns827_Networking_Solutions_White_Paper.html

Figure 2. Mobile Broadband Demand Versus Capacity



Average Demand per User versus Average Capacity per User

(Source: Mobile Broadband Capacity Contraints And the Need for Optimization - Rysavy research 2010)

LTE services can be deployed in new spectrum such as 2.6 GHz (Band 7), but it can also operate over existing 2G and 3G bands in many regions, including 1800 MHz. As a result, operators can re-farm parts of the spectrum currently used for 2G voice and data services to support LTE. LTE spectrum can also operate in a wide range of spectrum allocations (1.4, 2.5, 5, 10, 15, or 20 MHz), giving operators ample flexibility to deploy LTE services concurrently with existing 3G services. Ultimately, all of these capabilities will allow operators to better keep pace with growing mobile broadband demand, and provide a better experience to both LTE and 3G users.

LTE Stakeholders and Applications

In addition to network operators, a wide range of stakeholders stand to gain from the growing global evolution of LTE networks, including original equipment manufacturers (OEMs), application developers, engineering system designers and integrators, and many others who will benefit from the higher speeds and improved user experience that LTE enables.

Connected products and applications that will benefit from LTE include:

- Mobile consumer devices, including mobile video, gaming and business applications, which will immediately benefit from improved LTE capacity and a more seamless user experience
- Connected automobiles, which can make a wide range of broadband services available directly in the car
- Connected homes, where, as LTE brings the cost-per-bit for wireless data into the competitive range of fixed broadband services, mobile routers can potentially replace wired connections, expanding the addressable broadband market and reducing installation costs
- Enterprise networking, encompassing a range of potential applications from business continuity solutions, to temporary network connectivity, to broadband Internet services for employees
- M2M connected applications such as communication-enabled utility meters, health meters, and consumer appliances, which can benefit from the improved resource efficiency of LTE, even when they do not require higher data speeds

LTE1800: Re-Farming Band 3

The earliest launches of LTE networks are using the newly licensed 2.6 GHz spectrum (employed by nearly half of mobile operators deploying LTE networks, according to the Wireless Federation), and lower spectrum in the 700 to 800 MHz bands. However, more and more operators are turning to the 1800 MHz band as the most compelling and cost-effective option for LTE services. Indeed, the largest portion of FDD spectrum above 1 GHz is being allocated in Band 3. There are good reasons for this growing popularity. LTE1800 offers:

- **Better coverage:** GSA reports that LTE1800 supports a coverage area about double that of LTE deployed at the 2600 MHz band.
- **Increased capacity**: Band 3 is a wide spectrum (2x75MHz for FDD), offering the potential to support a very high-performance LTE service. This additional capacity can

be particularly useful in dense urban areas where, because LTE1800 can reuse existing infrastructure (see below) it can increase capacity without requiring new cell sites.

- **Enhanced user experience:** LTE1800 provides a strong signal that travels well over distance and in buildings, improving indoor data rates and battery life of LTE-connected devices.

- **Wide availability:** The 1800 MHz band is available in many parts of the world, especially in Europe, Asia and Oceania. LTE1800 terminals are now being developed by a number of cellular vendors and device manufacturers, and will be ready for mass market volume deployments in 2012—soon after LTE2600 deployments.

From the network operator's perspective, the biggest advantage of LTE1800 is reusability. Operators around the world already use the 1800 MHz band for 2G GSM services. (In Europe, Band 3 is strictly used for 2G voice and EDGE services.) As 3G services have come to dominate mobile networks in recent years, many operators now find this 1800 MHz spectrum underutilized. By moving current 1800 MHz band customers to 3G or 4G services (or even shifting 2G services to a lower frequency band such as 900 MHz), they can re-farm that 2G spectrum for LTE. For connected device manufacturers and LTE application developers, this strategy provides ample capacity for new LTE services and heavier data usage, while preserving the quality of current 3G services. Even shifting 5 MHz to LTE services can improve the user experience—and at a lower cost compared to 3G HSPA.

LTE1800 also helps operators deliver a more consistent experience to all customers. As more users come onto the network with a broader range of devices, some of those devices will function better on the network than others. The flexibility of LTE1800 makes it easier for operators to account for this by segmenting traffic—putting those devices that generate the most data traffic onto the part of the network designed for heavy data usage, for example, and offloading them from other parts of the spectrum. In this way, operators can provide a better experience for all users, including current and new customers.

Re-farming Band 3 also allows operators to launch LTE very cost-effectively—and from the connected device manufacturer's perspective, more quickly. Whether operators use the 1800 MHz band in lieu of or in addition to licensing new spectrum specifically for LTE, reusing existing spectrum can substantially lower that initial cost. Reusing 1800 MHz spectrum also provides a faster path to LTE, with less cost uncertainty, than waiting several

more years for “Digital Dividend” spectrum to free up. In addition to reusing spectrum, however, LTE1800 also allows operators to reuse existing GSM1800 infrastructure, antenna lines, and cell sites—and even enables operators to support LTE and 2G GSM services at the same sites simultaneously. Ultimately, LTE1800 lets operators shift to LTE “on the fly,” with minimal impact to existing customers and services, at a relatively low cost.

Because of these advantages, operators worldwide including Telstra, Deutsche Telekom, H3G, Vodafone and many others have zeroed in on the 1800 MHz spectrum band as the best option to support their LTE services. For device manufacturers and mobile application developers, of course, this is all good news: The more capacity and cost savings LTE can provide for operators, the more they can deliver outstanding user experiences at competitive prices. Indeed, a growing number of cellular manufacturers are now producing LTE1800 terminals and multimode LTE devices that support LTE1800, many of which are available now or will be in the next year.

Meeting User Requirements and Expectations

Clearly, LTE1800 holds enormous potential for the next generation of mobile broadband devices and services. Delivering on that potential in real-world devices and applications, however, can be a daunting design and engineering challenge.

Succeeding with LTE1800 means much more than designing products that can achieve peak LTE data rates. Manufacturers must aim to create products for the real world—where pockets of LTE coverage will be surrounded by large areas of 3G or even 2G service, and where the operator network will look very different five years from now than it does today. Fundamentally, device manufacturers must go beyond simply providing LTE1800 connectivity, and carefully evaluate the LTE modem or module technologies they are considering for their products. A decision made without considering all of the complexities involved in LTE1800 operation can lead to significant delays in getting a device certified and into the hands of users. In particular, OEMs should weigh a LTE modem or module’s multi-mode implementation, antenna design, and software integration, among several other factors.

Multi-Mode, Multi-Frequency Operation

When designing practical LTE1800 devices for real-world operating environments, OEMs will need to account for significant complexity. As compelling as the 1800 MHz frequency band is for LTE services, many operators will not deploy LTE as strictly a Band 3 service, instead implementing it in one of several band combinations. Some operators will deploy LTE at both the 1800 MHz and the new 2600 MHz frequency bands. Some European operators, taking advantage of the Digital Dividend, will combine 1800 MHz with the 800 MHz band (Band 20). Some operators may even use a combination of all three. In many cases, however, OEMs may well find that designing LTE1800 solutions for a particular market is an à la carte proposition, requiring some degree of customization.

Any viable LTE1800 solution must also support more than just LTE. Operators are racing to bring LTE services live, but LTE1800 network deployments are still in the very early stages. If operators are re-farming their frequency bands to support LTE—adding on LTE infrastructure to the existing network, rather than replacing it—the operating environment will necessarily include a larger combination of network technologies. Practical mobile broadband solutions will need to include good HSPA+, 3G HSPA, and even 2G radios in addition to LTE radios—often in multiple band combinations as well.

This means more operating states to account for and more extensive testing requirements. From a hardware perspective, it also means more components, more heat and more power consumption. Engineers must therefore design LTE devices, especially modems, to run as efficiently as possible and to draw heat away from all vital components. OEMs will also need to account for the fact that this is a fluid environment, and that operators will be migrating more data traffic to LTE over time.

Even more challenging than these hardware requirements, however, is negotiating handovers from one type of coverage to another. The problem is not simply maintaining the connection, although that is obviously vital, but preserving the best possible user experience. If a user is streaming a movie on an iPad, for example, and the connection switches from LTE to 2G, the effect is the same as if the connection cut out entirely. The LTE device must be intelligent enough to select the next-best option when roaming out of LTE coverage, whether that is HSPA+, 3G HSPA, etc., and hand off in a manner that is completely transparent to the user. Implementing that kind of intelligence is a significant undertaking.

Antenna Design

Good antenna design is critical for successful LTE operation, and requires an investment of time and resources that device manufacturers have not had to undertake since the early days of 2G and 3G networks. LTE relies on multiple-input multiple output (MIMO) antennas, which are more complicated than those used in previous-generation modules and modems. Engineers must account for balanced antenna structure and coherent distance (i.e., separation of antennas), as well as the polarity and even directionality of the antennas. Failing to properly address these requirements will have a much more noticeable impact on the user experience than is the case for standard diversity antennas used in 3G and 2G solutions.

The problem is compounded by the fact that LTE modems operate across more bands than 3G systems. In particular, the lower spectrum bands on which many LTE networks operate tend to pick up significant electrical noise from the host device or application. So antennas must be designed to not only address a more complex set of requirements, but to address them in a much noisier environment.

All of these considerations make LTE antenna design a much more challenging engineering problem, whether embedding a module in a device for an M2M application or building a mobile computing product. Solving this problem is even more important, however, when building devices for LTE1800. Since operators already use this spectrum for 2G services, many plan to use their existing 2G cell sites to support LTE1800, simply changing the 1800 MHz cells from 2G to LTE. As discussed, this strategy offers significant cost and speed-to-market advantages for operators. However, it does not result in the optimal cell site locations that might have been chosen if the network had been designed for LTE from its inception. To operate effectively in this environment then, good antenna and modem design are even more vital.

Modem Integration

The biggest issues users experience with wireless USB modems are often not caused by the wireless technology itself, but by problems in how the software initially installs on the user's PC. Given the increased complexity of LTE operation, it is therefore even more important to properly architect the software and installer design.

OEMs also need to design USB modem interfaces to accommodate the much higher connection speeds of LTE, and assure that the interface does not create bottlenecks between the modem and the PC. A successful LTE1800 solution should also include software and drivers that minimize CPU requirements, so that the host does not run out of CPU cycles just servicing the modem.

Testing and Validation

Since most LTE1800 deployments are still in the very early stages of deployment, OEMs should be prepared for the fact that wireless carrier testing protocols are far from mature. As a result, testing on the supplier side is even more important to assure a quality solution. OEMs and solution developers should expect to undergo a more extensive testing process than in the past. They should also seek to work more closely with network operators and network infrastructure vendors (or with LTE suppliers with strong relationships with these stakeholders) than they might have when developing devices for previous-generation cellular networks.

Best Practices for LTE1800 Connected Devices

Clearly, OEMs, system integrators and mobile application developers will need to carefully evaluate any LTE communications supplier with whom they are considering partnering. Given the unique complexity and novelty of LTE1800, the most important requirement is working with a partner capable of providing the largely customized communications solutions necessary to take full advantage of this emerging LTE technology. Ideally, OEMs and system integrators should be able to come to a cellular partner with broad business and technical requirements, and the partner should be able to guide them through all of the complexity to a successful rollout.

To provide this kind of partnership, an LTE1800 modem or module supplier should possess:

- **Proven expertise in multi-mode, multi-frequency solutions**: Given the inherently complex operational requirements of LTE1800 devices, OEMs should look for vendors with broad expertise not just in LTE, but also in 2G, 3G and HSPA+ technologies. Suppliers should have demonstrated success developing modems that can successfully operate

in multi-mode and multi-frequency environments, and intelligently navigate complex multi-mode handoffs. Suppliers should also be able to provide solutions with effective thermal dispersion and efficient power consumption, even as they incorporate more connectivity technologies and frequency bands into their product.

- **Broad knowledge in antenna testing and design:** Since antenna design is so critical to LTE1800 performance, OEMs and system integrators should seek out suppliers with expertise in this extremely specialized discipline and the equipment to perform antenna testing properly.

- **Expertise across multiple platforms**: An effective LTE1800 partners should know LTE inside out. Ideally, OEMs should seek suppliers that have developed LTE solutions for both end-user devices and embedded modules. This breadth of expertise affords greater confidence for the OEM or application developer, but also streamlines certifications with network operators, as it is easier for carriers to work with suppliers that can leverage a range of mature products with similar testing behind them.

- **Embedded intelligence**: Given the new and dynamic nature of LTE1800 and LTE in general, OEMs and M2M application developers should seek to build the most flexible solutions possible. Using solutions that can embed application intelligence as well as communication intelligence into the cellular module will afford them more agility to meet evolving customer and operator requirements.

- **Track record of successful modem integration**: The LTE supplier should have demonstrated success designing effective interfaces with computing devices, and good user interfaces and software installation.

- **Global expertise**: LTE1800 will operate over several different frequency band combinations depending on the carrier and geographic region. OEMs and system integrators should seek suppliers with extensive experience operating in many frequency bands and supporting operators who are re-farming parts of their spectrum. The supplier should also have the scale to be pursuing certifications with multiple carriers worldwide and the ability to offer pre-certified LTE solutions.

- **Advanced professional services, as well as technology**: Unlike with mature 3G and 2G technologies, OEMs and solution developers cannot simply buy an LTE1800 modem for their planned device. Indeed, most LTE1800 solutions will require some

degree of customization. Strong cellular partners will offer guidance throughout the process of integrating LTE communications into the device, and shepherding the solution through all of the various evolving certification processes. LTE suppliers should also be forward-looking, with an in-depth understanding of how different carriers and markets are proceeding with their LTE rollouts.

- **Solutions that are optimized for time-to-market**: With mature 3G and 2G technologies, OEMs and system integrators may choose communications solutions that diverge in small ways from the standard. With a new, complex standard like LTE, however, it is important to use solutions that strictly follow the standard. Rigorously applying the LTE standard may not mean optimizing for the lowest possible manufacturing costs, but it does make it much more likely that the device will be certified and able to meet planned launch dates. And, as LTE networks and technologies mature, costs will likely come down. Choosing LTE partners with close relationships with global network operators is also more important than ever to streamline device certification and rollout.

Conclusion

The next generation of LTE-connected devices promises a world of new mobile applications and unprecedented mobile experiences for users. Residing in the “sweet spot” of the spectrum to provide an excellent combination of capacity, coverage, cost and speed to market, the 1800 MHz band is providing an attractive option for network operators and device manufacturers alike. By carefully weighing the unique requirements of LTE1800 operating environments, device manufacturers, system integrators, application developers and other stakeholders can assure that their LTE1800 solutions deliver on the full promise of next-generation mobile broadband.